Spectrum of Engineering Sciences
ISSN (e) 3007-3138 (p) 3007-312X VOLUME 4, ISSUE 3, 2026

DIGITAL TWIN AND 6G: CHALLENGES, ARCHITECTURES, AND FUTURE RESEARCH DIRECTIONS

Muhammad Azhar Mushtaq[*1], Muhammad Kaleem[2], Hamza Zaheer[3], Muhammad Auon[4], Syeda Javeria Batool[5], Kashan Ahmad Khan[6]

[*1,2,3] *Departmnet of IT, Faculty of Computing & IT, University of Sargodha, Sargodha, 40100, Pakistan*
[4,5] *Departmnet of Computer Science and IT Thal University Bhakkar, 30000 Punjab Pakistan*
[6] *Department of Computer Science and IT NCBA&E, Multan, 66000 Punjab Pakistan*

[*1]azhar.mushtaq@uos.edu.pk

DOI: https://doi.org/10.5281/zenodo.21806477

Keywords
Digital twin, 6G , Challenges, Future direction

Article History
Received: 26 January 2026
Accepted: 11 March 2026
Published: 25 March 2026

Corresponding Author: *
Muhammad Azhar Mushtaq

Abstract

Due to the popularity of implementation of the fifth-generation (5G) mobile communication systems, the focus of research in the wireless community is now moving towards creating sixth-generation (6G) networks. Although 5G has been largely oriented towards assisting the greater industrial use, it is believed that 6G will be a basic infrastructure in the next generation of intelligent, autonomous and data-driven industries. In our perspective, this development is a major leap to high integrated cyber-physical systems.

Digital twin is expected to be a central part of this change. Digital twins have the potential to greatly enhance the monitoring, optimization, and decision-making of a system because they can help implement real-time virtual representations of physical entities. Together with the ultra-low latency, high reliability and enormous connectivity that 6G offers, digital twins will allow new applications in a variety of industrial and societal processes. Our convergence is deemed to be an important facilitator of intelligent environment in the future.

The present paper is a review of recent studies on digital twin technologies enabled by 6G technology. We consider new architecture, information and computing structures, and modeling of application scenarios. Moreover, we address the issue of key technical challenges as well as outline potential opportunities of future research that still needs to be tackled to achieve the full potential of digital twins in the 6G ecosystem.

1. Introduction

In recent development in software policy, artificial intelligence, machine learning, and high execution computing fast by graphic processing unit, DT have attained grasp in more diverse industries, like smart cities and manufacturing. It has become clear that many narrative applications and assistance will arise at the outset of the 6G wireless network, varying from extended reality, immersive multimedia, autonomous driving, network and computing convergence, and holographic communication. pervasive intelligence ,multidimensional sensing ,and beyond [1][2].these developments made by research and academic communities .A wide range of needs that were unachievable with earlier wireless technology generation must be addressed in order to enable many use cases [3].In order to support 5G use cases,

a number of cutting edge technologies have been raised ,and digital twin is also a emerging technology here to support development, optimization and operation of 6G wireless networks [4][5].The use of 6G technology in digital twin is the requirement to continuously assess the effectiveness and equity of quality of services policies through real time physical system behaviour its monitoring ,simulation, analysis, optimization prediction ,and design This approach can be applied to both moment and more complex system.
With the use of AI, which is a crucial factor in the development of 6G wireless network, Digit twin ay transform into a perceptive and cognitive intelligence generator by using a vast amount of historical and online network data [6]. The advent of 6G brings along a multitude of difficulties pertaining to the effectiveness, precision, safety, and resilience of digital transformation. The primary objective of (DT) for 6G is to consistently optimize physical networks by implementing well-balanced policy adjustments and management activities [7]. Hence, the integration of real-time sensing with AI technologies would be important in achieving the Digital Transformation for 6G. Furthermore, the demanding computational requirements of DT to achieve instantaneous contact and reaction entail expanding the computing power of physical devices beyond their inherent limitations. This, in turn, leads to the adoption of split computing, which is an emerging technology trend for 6G [8]. Furthermore, ensuring the reliability of physical networks that support digital transformation necessitates the implementation of flexible security measures, like solutions that provide security at the physical layer, transmissions without the need for keys, and distributed systems for detecting anomalies. Ultimately, the advancement of the DT concept to encompass the representation of the 6G environment and the interactions between DTs necessitates extensive information exchange through the transfer of a significant amount of data, with the requirements of minimal delay and high dependability[9]. In this regard, terahertz (THz) communication will be of most importance in 6G. Precise positioning capacities of Tera hertz and sub–Tera hertz systems can allow deep precision mapping of the physical environment to the digital realm conceivable [10]. In this discussion, we will explore the issues and future directionss of the digital twin and 6G.

2. Background

The convergence of digital twin and 6G promises a revolutionary future for communication network, facilitating real time monitoring, optimization and control on physical system in assorted sectors. Moreover, DT and 6G together can enhance network management, and optimized service delivery, it can transform cities into it can transform cities into smart cities, empowered with industrial mechanization.
However, this concept come with its challenges, such as. What can digital twin do with the combination of 6G? What are the technical or non-technical challenges in 6G which needs to be addressed. Are there any other requirements that is overlooked by researchers? To answer these questions this paper presents the answers by taking each point into consideration. Architectural evolution of 1G to 6G in section 3. Section 4 elaborates the challenges faced by DT and 6G. Future direction is presented in section 5 and future direction is discussed in section 6.

2.1. Evolution from 1G to 6G

2.1.1. 1G

During the 1G period, monopoly operators provide telecommunication, these drivers did not have to get spectrum and received it loose of charges. Now a day phone calls are not expensive but at that time phone calls, mobile equipment's and contribution were more expensive therefore only 10% of people use these services at that time [11].

2.1.2. 2G

2G had more competing systems than 1G .GSM more than 90% shares was control system level .this big favor of GSM can be put up to the procedure of contesting that was introduced in 2G.In the era of 2G along with the service of voice call the services of SMS and MMS services were also added.2G operated using digital modulation schemes .Digital data benefits of around 9.66 kb/s were supplied that level up to 35 kilobit per second with the intro of GPRS(General packet radio system)also a speed reached to 200 kilobits per second EDGE(Enhanced data rate for GSM evolution) [12].

2.1.3. 3G

In 2000,3rdG of mobile communication was introduced, its goal was to supply high speed transmission. Data transmission rate reach at 3G networks from 2mb/various services supported by 3G like TV streaming, web browsing, etc. The organization 3GPP was formed in order to establish technical statement ,and define mobile systems and standards so that global roaming was possible [12].

2.1.4. 4G

4th G communication system is an IP based network system. It was introduced in the late years of the preceding decades. The primary goal of 4G was to offer user higher speed, improved security, superior quality and greater capacity compared to 3G. Additionally, it offers voice and data services, internet and multimedia services over IP at affordable rates. The uplink speed for 4G is 500 megabits per second ,while the downlink speed is gigabit per second. Terminal mobility is a important aspect of 4G, as it enables automated roaming between different wireless networks. These techniques enable seamless roaming different wire technologies, such as OFDM and LAS-CDMA by integrating with both future and existing technologies [12].

2.1.5. 5 G

5G mobile communication networks are supposed to be accomplished with standardization process, construction of hardware space and after which they will be deployed for commercial usage. Main goals of 5g are advanced in data transmission rate, reliability, better connectivity energy efficiency and latency .5G is a game changer have potential to revolutionize many aspects of our lives. Different frequencies used with high-speed waves offering excellent performance but at limited range, while on the other hand 6G provide wider coverage see figure 1. In 5G data rate can be reached at high rate up to 10Gbs.Different advanced access technologies like BDMA, FBMC are employed in 5G. Some technologies of 5G are the millimeter waves communications [13].

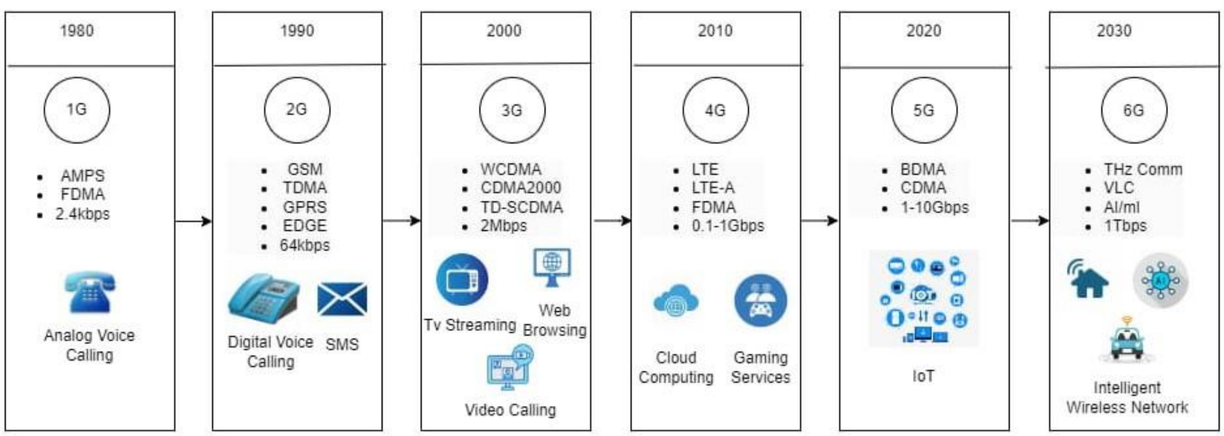

Figure 1. Wireless Evolution Road Map

2.2. 5G Technologies of 6G

2.2.1. THz Communications

For more data rates and bandwidths 6G forecast to use Terahertz band. Available bandwidth that is greater than mm waves band. THz communication provides 100Gb/s.THz communication available band of exceed than ten of giga hertz, using of short beating period and slim beam assures the chance of spy in vastly bring down. Decreasing the chance of low eavesdropping will provide high security [14].

2.2.2. Molecular Communication

MC utilizes chemicals and biological signals to transmit information, like the way real cells communicate. Nanodevices can be produced using sophisticated nanotechnology for applications in biomedicine and at the nanoscale. The nanodevices can also be interconnected to the internet and organized into networks to facilitate efficient communication of knowledge and communications. Subsequently these nanodevices can be employed for administering medication inside the bloodstream and monitoring the vital signs of body organs [15].

2.2.3. Visible light Communication

Oncor optical wireless communication s a complementary technology to RF-based mobile communication VLC, or visible light communication, utilize LEDs to achieve both high- speed data transfer and lighting purposes. With the continuous improvement in efficiency and lifespan of LED bulbs as well as advancements in associated technologies, VLC (Visible light communication) is expected to offer data rates of several hundred gigabits per second once 6G is implemented [15].

2.2.4.Artificial Intelligence

Artificial Intelligence, particularly ML, is already employed in 5G networks and several applications on mobile devices. AI has the proficiency to memorize, make prognoses, and make judgments through the usage of large data activity which enables AI the possibility of transform and replace areas that require models and proficient understanding in wireless webs.6G wireless networks are projected to be intelligent and data-driven, making AI a crucial technology for allowing autonomous networks. Additionally,6G is anticipated to utilize big data approaches. In order to make a diverse and complex network like 6G intelligent, it will need an AI paradigm that is self-aware, self-adaptive, visionary and prescribed. The KOC_Net model contains 05 convolutional blocks, and each convolutional block has three components such as Convlotuioanl 2D, ReLU, and MaxPooling 2D [16].

2.2.5.*Quantum Communication*

Quantum communication is anticipated to be a highly favorable approach for the growth of 6G. Quantum communication an increased grade of security by encoding information in quantum states using quantum particles, which makes it hard to intercept the information without being detected. Quantum communication allows for long-distance global communication through the use of quantum repeaters, which are capable of correcting operational errors [17].

3 Architectural Design

3.3. Architecture Digital Twin Enabled 6G

3.3.1. Twin Objects

Suppose the concept of twin object-based architecture for DT allowed 6G to qualify different applications on the internet. Commonly twin objects use a virtual model of the physical object and are then accountable for executing improvement, Machine learning model training, and power to the services of 6G. For virtually representing the physical object, there are a plenty of challenges like correct meditation of attributes, connectivity, and composability. Connectivity refers to truly finished information synchronization between a physical object and its digital twin objects, and composability pacts with existing twin objects of entities for facilitating twin-based services. 6G services can be deployed by utilizing single or multiple twin objects. Twin objects can be used to emulate a single entity, single service, and multiple services [18].

Twin can be utilized for the emulation of full services by end-to-end aid administration and planning. Twin objects can be dynamically instantiated and terminated to facilitate the functionalities of 6G. Twin objects can be created by utilizing a transient-based virtual machine, which enables proactive customization of resources. Twin objects provide proactive intelligent analytics through the utilization of retrained ML models for synchronous communication. Subsequently, the allocated resources for the TVM should be freed upon completion of the services. It is important to ensure that the total value management (TVM) for one assistance is retained and distinct from the TVM of another service. Additionally, it is necessary to isolate the TVM from the software running on the host node. The host node software must seamlessly and universally communicate with the TVM to efficiently implement many TVMs [19].

3.3.2. Twin Object Deployment Trends

Twin objects can be utilized in various categories such as edge, cloud base and edge cloud base digital twins. Edge base digital twin is more suitable for 6G because of its nearby location, cloud based digital twin is suitable because of use in deploy tolerant and use high power computation with large storage .and at the end edge cloud based digital twin exploit the benefits of cloud base twins. A comparison is given in table 1. For real time application twin object use pretrained models like ML models for better performance. For designing the traffic of 6G congestion control we can use cloud based digital twins[2].Various interfaces like twin to twin, twin to thing, twin to service interface must be use for isolation base, seamless, complicated interaction in a scalable and reliable manner [20]

3.4 Digital Twin Operational Steps

We can split twin operations into two classes, operation and training. For training one can use distributed ML (for service request). Next, local learning models are transmitted to twin layer for aggregation at the block chain miner (steps for authentication and then perform translation using semantic reasoning). Next the figuring of the global model, update sent to device for updating local learning models (twins objects installation based on farsighted analytics and block chain network of miners where perform pre-trained models and training of data also give the homogenized digital control instructions (in physical interaction layer) to gateway nodes acting as twin to thing interface. Then process perform synchronous or Asynchronous phase. In Asynchronous phase a device sends its local learning model only when bringing a relation from miners and in case of synchronous phase local learning model within a predefined time to miner for international /global aggregation. In step 1 perform service request, step 2 perform authentication, step 3 Application translation using semantic reasoning. Step 4 twin objects manifestation based on proactive analytics. Step 5 blockchain network of miner [21].

Table 1. Comparison of Edge based twins, Cloud based twins and Edge, Cloud based Twins.

Name	Description	Edge-based Twins	Cloud-based twins	Edge-Cloud based Twins
Geo- Distribution	In this we can see geo graphical distribution of twin objects for 6G services.	Distributed	Centralized	Hybrid
Scalability	Addition of new nodes and fulfilling the requirement of latency for 6G devices	High	Lowest	Low
Elasticity	Fulfilling the highly dynamic requirements. Refer metrics on demand of dynamic resource allocation.	High	Low	High
Context Awareness	It deals with the end device locations and traffic management.	High	Low	Medium
Reliability	Refer robustness in seamless operations of Detangled 6G application in case of failure of any twin object	Highest	Lowest	Medium

Use case and Requirements for Network of DT and 6G: DTNs (Digital Twin Networks) can support many use cases comprising, but not restricted [22].

- Network simulation and Planning: For decreasing the expenditures of aids and allotment in the material world.[4]. The grid deployment team first enhances the network simulation and planning procedure utilizing large-scale, physically valid digital replicas of city blocks or any system and test and optimize the different situations which physical system can face in real time [22].
- Network Operation and Management: A Digital twin network can be used to build digital replica of any physical real time system for getting its reliability, accuracy and apply configurations in different ways for better results. Maintain a whole system with its reliability [23].
- Data Generation by Simulation: In AI system ,6G networks, entry to actual world of system is vital without connection to real world it is not possible to get correct and accurate data set of the physical system.
- AI Training and Inference: Online tutoring plays a central role in 6G and later. I.e.: Deep reinforcement learning (DRL) founded closed loop. A neural system embedded in the DRL vendor will be continually revised in reaction to the environment. DTNs will be critical and important for AI-based network optimization and supervision in real time [23].
- What If Analysis: 6G is an active network operator; it will be able to alter central parameters and architecture in minutes and hours relatively than in months or years. DTN is a virtual sandbox that determines network wrong layouts such as security issues, and link bottlenecks, to facilitate the prognosis of the coming concert. DTNs can facilitate high-fidelity prognoses to lessen randomness in a system. The dedication of prediction outcomes from infiltrating drawbacks relies on how accurately the DTN can depict its material counterparts [23]

3.5. **Requirements**

3.5.1. Scalability

A physical system can prosper or shrink in ranking and DTN automatically modifies itself Flexibility and scalability are important attributes of DTNs.

3.5.2. Reliability and Latency

Reliability is the key characteristics of DTN. In the lifecycle of DTN needs reliable operational infrastructure, situation of dealing with human errors handling with equipment failure, real time response on malicious attacks, ensure data collection methods capabilities of disaster recovery and handling [24].

3.5.3. Generalizability

DTN applicable across different network equipment's, network applications require certain degree of compatibility. Specially in data collection, data storage, interfaces, modeling need to generalize to support different vendors.

3.5.4. Agility

Ability for unruly interchange data exchange and courtesy corporation between numerous digital twin commodities are some of the crucial traits of DTN toward session demands of assorted functional stages of physical network. So we need to have adequate flexibility in functionalities as needed [24].Figure 2 represents the requirements of 6G DTN with use cases.

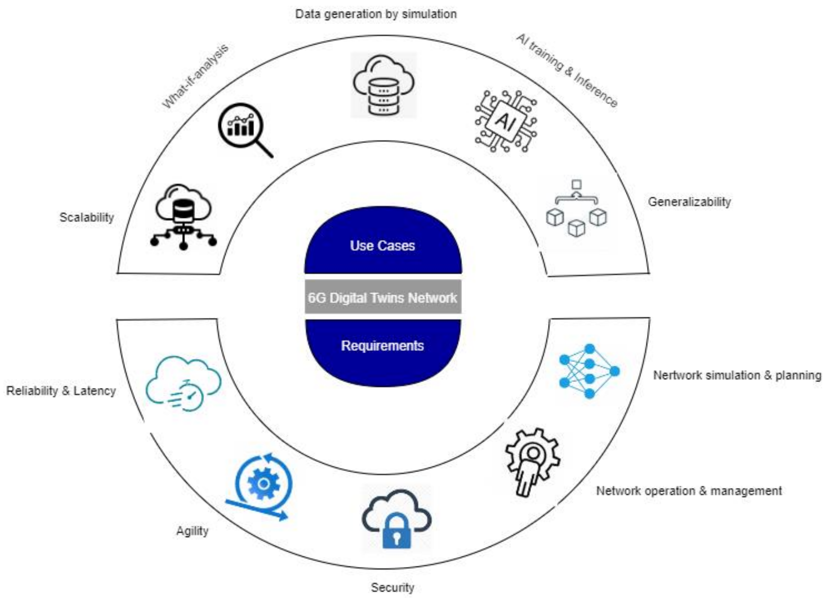

Figure 2. Requirements for 6G Digital Twin Networks

4. Challenges

4.1. Technical Challenges

4.1.1. High Fidelity Modeling

Several factors contribute in high fidelity modeling challenge in 6G:6G network is more complex and with more advanced technologies such as it has high level of frequencies, it has dynamic natures constantly changing weather conditions this means 66G environment need to adapt these situations [3]. 6G create numerous numbers of data a huge quantity. So efficiently collection of data, storage of that data and processing of that data is very important [3] We need more understanding for 6G for building accurate models. Inaccurate simulation may lead to low fidelity and cause more problems in system it can affect performance of system [25].

4.1.2. Real-time data Synchronization

As 6G can transfer data in high speed such as 1Tbps so for this speed need more efficient data processing, and delivery at this speed. 6G promises low latency no delay in data and any delay can create high distortion.6g contain high volume of data so efficiently processing and communication of that data in actual time is very important along with also maintain updation of digital twin. Real-time data synchronization may effect due to poor performance inaccurate prediction and loss of control [25].

4.*1.3. AI and Machine learning Integration*

6G network and digital twin provide the facility and use of AI and ML, because 6G contain a massive amount of data so that data analyzed by AI and ML so that to refine accurate digital twin these two also help in real time data synchronization , prediction analytics and in autonomous decision making .Data security and privacy challenge can come in digital twin enabled 6G, explain ability and transparency problem due to complex algorithms of AI .

4.1.4 Network Security Threats

Where 6G and digital twin both provide intelligent future and great results there also come number of complexities that cause many network security threats[3].there are different type of surfaces where come threats such as digital twin offers new data entry points which also give place to attacker for attacks[3], 6G provide massive amount of data so there come many places or areas where data breaches occurs and manipulation in data [26].

4.1.5. AI powered Network Slicing

It is important in network slicing for complexity management, optimizing overall performance of network, predictive maintenance, it helps in self-healing capabilities. So where it has some benefits it come along with some challenges such as AI model become more complex and there decisions also transparent from the sight of human it may cause explain ability and transparency challenge, data privacy and security challenge for managing this complex system overall the strong infrastructure knowledge and skills are required[26]

4.1.6. Dynamic Network Slicing and Resource Allocation

6G is fast speed, having flexible network slicing capabilities processes to revolutionize that resources. The maintenance and allocation of resources is complex in real time, balancing of data from one network to another different network and different slices by shifting on demand because challenges such as heterogeneity, dynamic nature, uncertainty, prediction, scalability and efficiency challenges [6]. Inefficient resource allocation can lead to bottleneck in some slices. Improper resource allocation can make vulnerabilities inaccurate prediction about future and can lead to costly infrastructure and increase resource burden plus cost [26].

4.1.7. Synchronization Complexity

The high speed, dynamic network slicing and promises of revolutionize communication insurance of digital twin perfectly connect with its physical counterparts come with synchronization complexity. This could be a challenge due to ultra high speed, because of a tiny delay can cause system out of synchronization, low latency any leg can destroy real time representation, dynamic network slicing, maintaining synchronization at multiple independent slices cause problem In synchronization. Diverse data sources digital twin integrate data from different sources so inconsistency in data odd any delay cause synchronization problem[27].

4.1.8. Scalable and Efficient data Processing

6G contain massive data from sensors, different devices and network. Different other devices for data source, dynamic network configurations, requirement of low latency, resource constraints for scaling data processing to handle massive amount of data volume. While maintaining efficiency of system and resources is difficult and could cause inaccurate digital twins, increased cost and infrastructure and long delays [27].

4.1.9. Cybersecurity Threats and Vulnerabilities

6G and digital twin promises are higher connected future of high-speed intelligence. But where we get more advantages face also certain challenges like cybersecurity threats and vulnerabilities. Expanded entry point in digital twin, interconnected system and massive data can cause huge threats and vulnerabilities [28].

4.2. Non Technical Challenges:

4.2.1. Standardization

Without standardized protocol, architecture and data format digital twins will be incompatible lack of clear standards may cause scalability issue also to effect on performance and efficiency of digital twins. Standards are essential for security and privacy measures without it there are no integrity and reliability of 6G digital twin [29].

4.2.2. Security and Privacy

6G and its digital twin counterparts promises a hyperconnected future of high-speed intelligence. But for there big demands navigating the crossroads of security and privacy digital twin introduce new entry points not only on side of physical counterparts but also available at digital side. Therefore, it is impacting on personal data in the shape of different systems are interconnected and gathering of data from different sources cause data security privacy breaches while any attack can compromise the sensitive data. Because of massive amount of data, it possible the cause of waste target area for potential breaches and manipulations [29].

4.2.3. Ethical Considerations

Ethical consideration is important for data privacy and ownership. Digital twins collect massive amount of data and then determining who owns and how this data will be used and who will be able to assess data. Ensurance of fairness and ethical AI development is important for the prevention of discrimination and promote responsible innovation. Building trust requires transparency and clear accountability for potential wrong impacts. We must consider the ethical implications of technologies that ensure to be sustainable and equitable future.

Need robust frameworks for ethical AI development and for transparency of digital twins [29].

4.2.4. Environment Impact

Digital twin enabled 60 promises benefits however along some challenges, so creating and maintaining of complex systems, like digital twins lead to increased energy consumption for data processing, transmission and storage powering such huge infrastructure demand significant energy. Technology advancements are going toward smarter world if do not follow proper disposal of previous technologies or equipment than it may cause e-waste generation. If sustainable mining practices are not followed than lead to environment degradation. It may cause electromagnetic radiation, data security and privacy breaches [30].

4.2.5. Social Inequalities and Exclusion

This emerging technology poses some significant challenges related to social inequalities and exclusion such as, due to geographical limitations, unequal access to 6G infrastructure and devices can lead to digital divide in term of different opportunities like in education, healthcare. Lack of training and skills can leave vulnerable populations struggling to adopt this technologies advancement. Digital twin and 6G rely on data collection and its analysis and this may to discriminatory outcomes due to biases inherent in data collection method. So these challenges could include lack of control and ownership may cause unequal distribution of benefits [30].

4.2.6 Cost and Investment

Translating the vision of digital twin and 6G cause significant cost and investment hurdles. There needs careful consideration. Supporting to dense network of base stations where require widespread 6G coverage demand for a healthy financial source. Creating and maintaining of complex digital twin require a healthy amount of cost and investment challenge cause due to rapid technologies advancement, data storage and processing, cybersecurity measures and other standard etc.

4.2.7. Accountability and Responsibility

Commonly defined responsibilities for data quality is very crucial because digital twin rely on data inputs and basis inherent, In data collection cause discriminant outcomes. Handling of system malfunctions and failure demand of responsibilities and accountability. Management of system security and privacy demands of responsibility consideration and transparency is necessary. This issue may cause more complexities such as distributed nature of system, evolving technology and regulations some unforeseen consequences [31].

4.2.8. Accessibility and Affordability

Esurance of universal accessibility and affordability present some challenges first look at accessibility it may cause digital divide due to unequal access to 6G infrastructure [18]. It may lead to physical and cognitive limitations, language barrier, 60 needed multilingual interfaces for accessibility [16], second affordability challenge it come due to high infrastructure cost , device cost and subscriptions, data cost and due to connectivity fees, it is complex [31].

4.3. Data management and integration challenges

4.3.1 Data volume and velocity

The sheer volume of data can overwhelm and overburden current storage and processing. Demand of instantaneous analysis to ensure efficiency and accuracy of digital twins caused data velocity challenges. And due to unmanaged data caused slow simulation and performance, storage and latency issue and security and privacy concerns.

4.3.2. Data heterogeneity

Facing heterogeneity hurdle due to multiple data sources, integration and interoperability challenges and ensurance of data quality and consistency is also difficult. Issues of outliers and biases can cause of impact on accuracy and simulation of data. For mitigation these issues need data standardization and harmonization, data integration and fusion technologies etc. [32].

4.3.3. Data ownership and sharing

Determining of data ownership right is very necessary, especially when collecting data from various sources. Complicated ownerships of data can claim and raise questions about accessing and sharing of data There's come issues of intellectual property concern, if legal and regulatory frameworks do not adequately address the complexities of digital twin create uncertainty and potential disputes.

4.3.4. Data accuracy and consistency
Sensor quality and calibration is important because it directly impacts on accuracy of collected data. Ensuring data integrity and consistency throughout the collection, transmission and storage is complex and critical any types of errors or attacks could be possible maybe human error can compromise data accuracy some types of bias can distort reality and can lead to inaccurate insights. Digital twin models need to be continuously validated and updated to reflect real time digital system latency or delay issue can break the chain of consistency and also real time synchronicity [33].

4.3.4. Open platforms and ecosystems
Closed ecosystems discourage open innovation and limit in development. Lack of interoperability standards can create data silos hinder in data sharing, closed platform technologies can lead to vendor lock-in. For unlocking ecosystem potentials need more standards lack standards cause open platform challenge. Open platform concerns about cyber attacks and data breaches. Robust security and privacy measures needed if open platforms are not scalable then it may cause issues in performance of complex system.

4.3.4. Bias and fairness
Unchecked biases can have consequences, vulnerabilities, biases inherent in data. when data collected from different sources, if biases inherent at design time and development time then cause discriminatory outcomes, effect different areas such as resource allocation etc. Human biases can creep into the system through decision made during model development. Bias causes discrimination and exclusion, unfair and unethical decision, erosion of trust and public acceptance. Proactive biases detection and mitigation is necessary on time [33].

4.5. Social and Economic Challenges
4.5.1. Digital divide
In this challenge face unequal infrastructure, costly technology and digital literacy gap [18]. In costly technology because digital twin requires hardware, software and expertise. It can create financial barriers for organizations and lack of literacy gap can hinder people's ability to participate in digital benefits. There also come the issues of loss of control are limited control over data due to imbalance in data [34].

4.5.2. Job and Automation
Digital twin and 6G combination revolutionized the industry. Due to revolution, there come job displacement because everywhere there is automation in every work such as in analysis, monitoring, processes also in decision making led to job displacement in specific sectors. So now the nature of work require new skillsets for development, maintenance, data interpretation and also in design, so if person have new updated and upgraded skill set so he is applicable in industry of revolution .There are new roles in ecosystem enhanced productivity and efficiency so need to focus on higher order skill set required reskilling and upskilling programs, safety Nets and also focus on ethical AI and social responsibility [34].

4.5.3. Public Trust and Transparency
Widespread adoption can create problem on building public trust and insurance of transparency. Complex algorithms are used in digital twins which lead to concern about bias, discrimination and lack of accountability. We can also share real data through digital twin which cause security and privacy problems. Limited public understanding can lead to misconceptions, misinformation and mistrust. For solving the issue need to be open in explain ability need best privacy frameworks and need meaningful public management [35].

4.5.4. Misinformation and Manipulation
There are differ rent and various cause for wide spreading of misinformation and manipulation [16]. Digital twins generate hype- realistic simulation which make it a easier to spread misinformation and loss to public trust. Malicious actors can exploit the data and algorithms which always use in digital twin to manipulate information. This challenge may face erosion of trust, social cohesion, economic, political

instability and ethical dilemmas and privacy violation we need to combat with this challenge by media literacy and education about system awareness.

4.5.5. Intellectual Property Right

Digital twin technology holds algorithms, software, data models, hardware and many more to operate a digital twin and it all holds intellectual property rights protection. All types of Innovations hold intellectual property rights. But identify real owner of specific aspects in this complex system is difficult. Balancing data ownership rights sometimes difficult deciding the scope of intellectual property rights protection for essential technologies which used in 6G standards while ensuring fair and licensing adoption require careful consideration we need to have contractual agreement, collaborative innovation models, flexible intellectual property right regimes and international cooperation and harmonization [35].

4.5.6. Global Competition

Nations strive to become global leader in digital twin and 6G technology to gain more economic advantages, source technological dominance. There is also a race of intellectual property which could create intensive competition among corporations and research institutions. These challenges cause geopolitical tensions and fragmentations, unequal access and development, and cybersecurity threats along vulnerabilities. Mitigation of these risks need standardization to focus on open innovation and collaboration and need cybersecurity frameworks [36] .

5. Future Direction

Future digital twins and 6G is to be filled with exciting likelihoods, encouraging to reshape industries, redefine human-machine relations and create solutions for complicated challenges across different domains. We can hope to see even more creative applications and improvements in this exciting area .By overwhelming challenges and assuring moral considerations ,this powerful mixture can revolutionize how we interact with physical world directing to a more efficient, endurable and personalized future. The future direction for both appearing technologies is to permit 6G to operate twin objects for diverse applications for the efficient usage of network aids is crucial. Furthermore, the pre-trained twin models can be further trained for more effective results, and pre-trained machine learning models for the digital twin will promote wireless systems to make on-demand decisions for various services. Moreover, Need to investigate key enabling technologies for vision on plenty of technical gaps that are still to be bridged. The roadmap to overcome the challenges is full of hurdles. Need more research on challenges and their solutions which can overcome them.

6. Conclusion

The integration of the digital twin technology into the sixth generation (6G) communication networks can be considered as one of the promising directions of the further development of intelligent and autonomous systems development. Using the ultra-low latency, high reliability and native intelligence that is envisioned to be implemented in 6G, digital twins could facilitate real-time alignment of the physical and virtual worlds, which would then ease state-of-the-art monitoring, prediction, and control of various application sectors.

This paper has provided the current research landscape of 6G-enabled digital twin technologies, including some of the architectural designs, enabling communication and computing technologies, and examples of use cases. This paper has helped to realize that even though there is a rapid development, there are several major issues that are still not solved. These are scalability, data security and privacy, interoperability, real-time model update and tight coupling between communication, computation and intelligence.

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